Hardy Hydroelectric Plant,
Embankment
6928 East 36th Street
Newaygo Vicinity
Newaygo County
Michigan

HAER No. MI-100-A

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
United States Department of the Interior
National Park Service
Great Lakes Systems Office
1709 Jackson Street
Omaha, Nebraska 68102-2571

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HISTORIC AMERICAN ENGINEERING RECORD

HARDY HYDROELECTRIC PLANT, Embankment

HAER No. MI-100-A

Location: 6928 East 36th Street
Newaygo Vicinity
Newaygo County
Michigan

UTM: 16:610380:4815970 (NW point)
16:610990:4815480 (SE point)

Quad: Croton

Dates of Construction: 1929-1931

Engineer: Edward M. Burd, head of civil and hydraulic engineering for Consumers Power Company, Jackson, Michigan, 1921-1929

Present Owner: Consumers Energy Company (formerly Consumers Power Company), Jackson, Michigan

Present Use: Impounds water for hydroelectric generating plant

Significance: The 120'-high Embankment is part of the Hardy Hydroelectric Plant, built in the early 1930s as a link in Consumers Power Company's system of electric power generation. In designing and building Hardy, the company found a way to erect a stable, relatively high dam on Michigan's notoriously gravelly foundations, continuing its tradition of developing solutions to the problems presented by Michigan's geography and geology. The design process for the dam also appears to reflect a tendency in American civil engineering to favor regional practices over technology developed elsewhere.

Project Information: This documentation was prepared by Consumers Power Company (CPCo) in conformance with its Cultural Resources Management Plan for the Muskegon River Hydroelectric Projects (July 1995). The plan stipulated the recordation of the entire Hardy Hydroelectric Plant (according to the standards of the Historic American Engineering Record). The documentation was completed in 1997 by Hess, Roise and Company of Minneapolis under contract with CPCo. Cynthia de Miranda served as Project Historian under the supervision of Principal Investigator Jeffrey A. Hess. Photographer Clayton B. Fraser of Loveland, Colorado, worked under a subcontract with Hess Roise.

PHYSICAL DESCRIPTION

The Embankment that impounds water in the Muskegon River for the Hardy Hydroelectric Plant (HAER No. MI-100) is a 2,600'-long earthen dam aligned on a northwest-southeast axis.[1] Designed for a hydraulic head of about 100', the structure rises to a maximum height of 120' above the riverbed and creates a storage pond of nearly 4,000 acres. The Embankment, about 1,000' wide at its base, narrows to a 25'-wide crest that carries a paved two-lane road. The upstream (north) slope has a grade of 1:4 at the crest that flattens to 1:5 towards the base. The downstream (south) slope is somewhat steeper. From a grade of 1:2 near the crest, it flattens to 1:2.5 at mid-slope, and again to 1:5 near the base.

A corewall reinforces the Embankment and makes it less pervious to water. The concrete wall is embedded 30'-6" upstream from the centerline of the Embankment. Concrete facing, jointed to the top of the corewall, sheathes the portion of the upstream slope above the corewall and terminates in a vertical splashwall about 10' upstream from the Embankment's centerline. The concrete splashwall provides about 10' to 11' of freeboard and acts as a railing along the highway across the dam's crest.

The downstream side of the Embankment is drained by a trench housed in the rock-filled base of a timber railroad trestle that was used during construction to transport fill for the dam. A series of tile headers laid perpendicular to the trench extend toward the downstream toe. The headers terminate in a tile collector that runs parallel to the trench and disposes of drained water into the tailrace. This outlet also allows measurement of drained seepage.

Above ground, a few structures are situated on the Embankment's downstream slope: the Powerhouse (HAER No. MI-100-B) and Oil House (HAER No. MI-100-F) at the southeast end; the Dormitory (HAER No. MI-100-G) in the center near the toe; and the concrete-lined Emergency Spillway (HAER No. MI-100-E) on the northwest end of the dam. A narrow flight of concrete stairs east of the Powerhouse provides access from the toe of the downstream slope to the crest of the dam.

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[1] For the sake of clarity, full cardinal points will be used in descriptions from this point. The description is based on: a survey completed by the authors on 24 July 1995; engineering articles; documents produced by Consumers Power Company; and an interview with Charles Smith, the plant's superintendent, conducted by Jeffrey Hess. See Edward M. Burd, "Hardy Dam Provides 40,000 Hp. for Michigan Peak Loads," *Power Plant Engineering* 36 (1 March 1932): 194-198; Burd, "Location and Design of Hardy Hydro Plant," *Au Sable News* 17 (August 1931): 3-6, 28-31; "Hardy Dam Goes on the Line," *Electrical World* 99 (27 February 1932): 412-413; Leo G. Stearns, "Investigation of Hardy Dam," Bachelor's Thesis, Michigan State College, June 1948; "Consumers Power Company's Hardy Dam: An Invitation to Recreation," Consumers Power Company brochure, undated; "Hardy Dam," 1933 summary of plant's features, historical files, Civil/Mechanical Engineering Projects, Engineering and Construction, Consumers Power Company, Parnall Road, Jackson, Michigan; and "General Plan and Section of Dam and Powerplant, Hardy Plant, Muskegon River, Figure No. 10," Hydro Operations, Consumers Power Company, Cadillac, Michigan.

HISTORY

Hardy Hydroelectric Plant was designed in the late 1920s as a link in Consumers Power Company's (CPCo) system of electric power generation. CPCo had spent the first quarter of the twentieth century refining a standard design for its hydroelectric power plants. The company derived its dam-building practice from that of William G. Fargo, a Jackson, Michigan, civil engineer who made the design of small- to medium-head earth dams on the soft, gravelly stream beds of Michigan his specialty. Fargo began building for CPCo in 1899 at the Trowbridge Plant on the Kalamazoo. As head of the Fargo Engineering Company, he designed more than twenty dams for CPCo, including those at the Croton and Rogers plants on the Muskegon River, before retiring in 1925.[2]

At the site selected for the Hardy Hydroelectric Plant's dam, no solid rock was available for use as a foundation. Fargo's work, however, had demonstrated that a reliable embankment could be built on Michigan's gravelly stream beds. At most sites, Fargo's strategy for making a dam relatively impenetrable to water seepage was to employ a combination of steel sheet piling and reinforced-concrete corewall. Crews first drove a sheet-piling cutoff into the most impervious section of the streambed, usually a layer of compacted glacial silt known locally as "mudstone." They then poured concrete for the corewall directly above the underground sheet-piling cutoff. Workers employed semi-hydraulic means to construct the dams, hauling embankment material to the river channel in railroad dump cars and using high-pressure streams of water to direct fine sands to the center of the dam and progressively coarser materials to the outer layers. Civil engineers had adapted the hydraulic method from techniques Western placer miners developed for separating metals from gravel.[3]

The 100' head proposed for the Hardy plant, however, exceeded by 30' any other CPCo development, a significant increase for a system comprising mostly low-head dams. All parties agreed that the project's size and its location in a populated river valley called for a conservative plan, since failure would be catastrophic for the company and for communities downstream. Edward M. Burd, head of civil and hydraulic engineering for Commonwealth

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[2] W.W. Tefft, "System and Operating Methods of Consumers Power Company," *Power* 55 (4 April 1922): 526-530; Charles K. Hyde, "Croton Hydroelectric Plant," HAER No. MI-81-A, 1994, Historic American Building Survey/Historic American Engineering Record Collection, Library of Congress, Washington, D.C., 3; and Commonwealth Cultural Resources Group, "Hydroelectric Plant Historical Review" (prepared for Consumers Power Company, Jackson, Michigan, April 1991), 11. Also see articles authored by Fargo: "Earth Dams," *Au Sable News* 6 (December 1920): 8-10; and "Hydraulic Excavation and Dam Building at the Croton and Lyons Dams in Michigan," *Engineering News* 58 (24 October 1907): 429-431.

[3] Tefft 527; Duncan Hay, *Hydroelectric Development in the United States, 1880-1940* (Washington, D.C.: Edison Electric Institute, 1991), 53.

Power Corporation—the planning subsidiary for CPCo—began to see that safer, more costly construction could be an important investment for the company.[4]

Specifically, Burd wanted to replace the customary central corewall with concrete paving on the face of the dam's upstream slope. "That portion of the embankment upstream from the vertical corewall merely holds the wall in position, having no value for water-tightness," Burd wrote to Commonwealth's chief engineer William Wolcott Tefft in 1926. "It has always been realized that the ideal construction would place the corewall or water cut-off at the upstream slope, greatly increasing the so-called percolation distance thru [*sic*] the embankment, which is the real measure of its safety. Owing to the greater length of upstream slope and the possibility of unequal settlement, it has never before seemed either economical or advisable to lay the concrete facing on this slope in our work."[5]

The facing method was controversial, however, especially in a state with soft foundations given to settling under loading. Despite Burd's supporting research, the company rejected concrete facing for the Hardy Dam. Fargo's formula was, in the end, employed at Hardy with a few modifications. The final design placed the sheet-piling cutoff and the reinforced-concrete corewall 30'-6" upstream from the centerline of the dam. A short section of concrete facing covered the part of the upstream slope above the top of the corewall to protect against wave action. The facing terminated in a vertical splash wall.[6]

Another Consumers Power Company subsidiary, Allied Engineers (formerly Stevens & Wood), oversaw construction of the plant. Work began in autumn 1929. Crews drove the sheet piling cutoff in December, starting at the banks and moving toward the center of the natural river channel. At the same time, they poured the concrete sleeves for the steel penstock tubes that would run beneath the embankment to connect the Intake Tower (HAER No. MI-100-D) and the Powerhouse (HAER No. MI-100-B).

By August 1930, the progress made on the penstocks enabled crews to divert the river through the tubes. Sections of corewall had already been laid near the banks, and workers were also erecting the timber trestle that would be required for sluicing the Embankment fill into place. Embankment slopes were taking shape by October.

Crews continued placing fill for the Embankment, which must have been complete when the concrete work on the Emergency Spillway (HAER No. MI-100-E) began in March 1931.

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[4] Burd to Tefft, "Oxbow Report", Commonwealth Power Corporation, Jackson, Michigan, 12 December 1926, in historical files, Hydro Operations, Consumers Power Company, Cadillac, Michigan.

[5] Ibid.

[6] Burd, "Location and Design," 5.

Nearly 1.5 million cubic yards of fill went into the Embankment. Sod laid on the Embankment's downstream slope protected it from erosion, and a narrow concrete staircase installed east of the Powerhouse (HAER No. MI-100-B) provided access from the downstream toe to the roadway along the crest of the dam. Spring runoff in 1931 filled the pond north of the Embankment.[7]

The Embankment has changed little in appearance since the plant was completed in 1931. The road across the dam was paved after 1950, and the light standards that originally illuminated the roadway were removed sometime after 1956. A chain-link fence preventing access from the road to the downstream slope was installed at an undetermined date.[8]

In September 1986, heavy rains caused a 250-year flood in the Muskegon River Valley, prompting fears that area dams might fail. At the Hardy Pond, the water level rose 8" above the Emergency Spillway's (HAER No. MI-100-E) splashwall crest before receding, and flood water flowed over the crest of the Emergency Spillway throughout a twenty-four-hour period. The plant operated at full capacity to ease pressure on the dam, but water leaked through the construction joints in the spillway's concrete chute. Despite the leaks, the Embankment held through the flood. Soon after the flood, the voids created beneath the spillway's concrete slabs were filled with grout, and construction joints were caulked to prevent a similar damage in future floods.[9]

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[7] A. M. Komora, "Construction of Hardy Dam Progresses," *Au Sable News* (December 1930): 5.

[8] A.E. Gramm to E.V. Sayles, 14 July 1950, Consumers Power Company, Jackson, Michigan, in historical files, Hydro Operations, Consumers Power Company, Cadillac, Michigan.

[9] Also see a "Storm Round-up" press release issued by Consumers Power Company on 18 September 1986, in Public Relations, Consumers Power Company, Jackson, Michigan.

## SOURCES OF INFORMATION

DRAWINGS

"General Plan and Section of Dam and Powerplant. Hardy Plant, Muskegon River, Figure No. 10." Hydro Operations, Consumers Power Company, Cadillac, Michigan.

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